

Water-Drinking Hydrotherapy for Blood Glucose and Anxiety Outcomes in Patients with Type 2 Diabetes Mellitus: A Quasi-Experimental Study

Dewi Aryani^{1*}, Aris Citra Wisuda², Dian Emiliyasi³, Rinda Suciarti⁴, Citra Suraya⁵,
Risdayanti Raharjeng⁶

¹Nursing Study Program, Sekolah Tinggi Ilmu Kesehatan Bina Husada, Palembang 30131, South Sumatra, Indonesia. Email: dewiaryanitik93@gmail.com *Corresponding author

²Nursing Profession Study Program, Sekolah Tinggi Ilmu Kesehatan Bina Husada, Palembang 30131, South Sumatra, Indonesia. Email: ariscitrawisuda.edu@gmail.com

³Nursing Study Program, Sekolah Tinggi Ilmu Kesehatan Bina Husada, Palembang 30131, South Sumatra, Indonesia. Email: dianemiliyasi.ners@gmail.com

⁴Nursing Study Program, Sekolah Tinggi Ilmu Kesehatan Bina Husada, Palembang 30131, South Sumatra, Indonesia. Email: rindasuciarti1997@mail.ugm.ac.id

⁵Nursing Study Program, Sekolah Tinggi Ilmu Kesehatan Bina Husada, Palembang 30131, South Sumatra, Indonesia. Email: citrasuraya.edu@gmail.com

⁶Nursing Study Program, Sekolah Tinggi Ilmu Kesehatan Bina Husada, Palembang 30131, South Sumatra, Indonesia. Email: risdayantiraharjeng@gmail.com

Abstract

Type 2 diabetes mellitus is a chronic disease characterized by hyperglycemia and may be accompanied by psychological problems, including anxiety. Oral water therapy is a simple complementary intervention that may support blood glucose control; however, its effects on blood glucose levels and anxiety require further investigation. This study aimed to determine the effectiveness of oral water therapy in reducing blood glucose levels and anxiety among patients with type 2 diabetes mellitus at Sriwijaya General Hospital, Palembang. This quantitative study employed a quasi-experimental pretest-posttest design. A total of 42 respondents were divided into a blood glucose group and an anxiety group, with 21 respondents in each group. The intervention consisted of consuming eight 200-mL glasses of water daily for seven days. Blood glucose levels were measured using a glucometer, while anxiety was assessed using the Hamilton Anxiety Rating Scale (HARS). Data were analyzed using the paired-samples *t*-test and Cohen's *d*. Blood glucose levels decreased across all measurement days, from 232.7 to 218.2 mg/dL on day 1, from 218.9 to 204.8 mg/dL on day 3, from 203.5 to 191.5 mg/dL on day 5, and from 189.8 to 177.4 mg/dL on day 7. All changes were statistically significant ($p < 0.001$), with very large effect sizes (Cohen's $d = 2.907$ – 3.739). In contrast, anxiety scores did not show a statistically significant change ($p > 0.05$), with very small to small effect sizes. Oral water therapy may support blood glucose control as a complementary intervention but did not demonstrate a significant effect on anxiety.

Keywords: type 2 diabetes mellitus, oral water therapy, blood glucose level, anxiety, HARS.

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INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a chronic metabolic disorder characterized by impaired insulin action and progressive disruption of glucose homeostasis. The global burden of diabetes has increased substantially, reaching an estimated 830 million people in 2022, with T2DM accounting for the majority of cases. Persistent hyperglycemia can cause progressive vascular and organ damage and increase the risk of cardiovascular disease, kidney disease, neuropathy, visual

impairment, and other diabetes-related complications (WHO, 2024). Therefore, maintaining adequate glycemic control remains a fundamental component of diabetes management and requires an integrated approach involving pharmacological therapy, healthy behaviors, nutritional management, physical activity, and continuous self-management support (ElSayed *et al.*, 2023; Tanaka *et al.*, 2020).

The clinical relevance of this issue was also identified at RSU Sriwijaya Palembang during a preliminary assessment involving 150 patients with T2DM. Of these patients, 95 reported concerns related to elevated blood glucose levels, while 55 reported anxiety. These preliminary findings indicate the need for complementary approaches that may support glycemic management while simultaneously addressing the psychological well-being of patients with T2DM.

In addition to metabolic complications, T2DM may also be associated with psychological problems, including anxiety. The chronic nature of diabetes, long-term treatment requirements, concerns regarding disease complications, and the need for continuous self-management may contribute to psychological distress among individuals living with diabetes. A systematic review and meta-analysis demonstrated a significant association between diabetes and anxiety symptoms, while more recent evidence has highlighted a bidirectional relationship between diabetes mellitus and anxiety (Amiri & Behnezhad, 2019; Mersha *et al.*, 2022). However, longitudinal evidence concerning the directionality of the relationship between diabetes and anxiety remains inconclusive, indicating the need for further investigation of anxiety among individuals living with diabetes (Smith *et al.*, 2018). Accordingly, addressing psychological well-being alongside glycemic control is an important component of comprehensive diabetes care.

Adequate hydration has been proposed as a potential factor influencing metabolic health through pathways involving arginine vasopressin (AVP) and its surrogate marker, copeptin. When fluid intake is inadequate, increased AVP secretion promotes water conservation and has been associated with unfavorable glucoregulatory and cardiometabolic profiles. Although the relationship between hydration status and metabolic health is complex and may be influenced by factors beyond fluid intake alone, previous evidence suggests that water consumption and AVP-related pathways may play a role in glucose regulation (Carroll & James, 2019; Vanhaecke *et al.*, 2021). Population-based evidence has also indicated that higher water intake and lower urine osmolality are associated with lower copeptin concentrations and a more favorable metabolic profile, supporting the potential relevance of hydration-related mechanisms to metabolic health (Brunkwall *et al.*, 2020).

Previous intervention studies have provided evidence that water intake may influence glucose regulation, although findings have varied according to population characteristics, intervention duration, and water-consumption protocols. In patients with T2DM, reduced water intake has been reported to impair glucose regulation, suggesting that inadequate hydration may adversely affect glycemic responses (Johnson *et al.*, 2017). Conversely, a randomized controlled trial found that water consumption before meals was associated with improved glycemic control among patients with T2DM (Sedaghat *et al.*, 2021). Increased water intake has also been associated with changes in copeptin concentrations and glucoregulatory parameters (Enhörning *et al.*, 2019). Furthermore, a systematic review and meta-analysis of observational studies reported an association between water intake and the risk of T2DM, further supporting the potential relevance of habitual water consumption to metabolic health (Janbozorgi *et al.*, 2021).

Nevertheless, evidence regarding the effects of increased water intake on glycemic and psychological outcomes among patients with T2DM remains limited and inconsistent. Previous studies have examined different water-consumption protocols, intervention durations, and

metabolic outcomes, whereas evidence concerning the potential effects of structured oral water consumption on anxiety among patients with T2DM remains scarce ([Hakam et al., 2024](#)). The present study addresses this gap by evaluating a standardized oral water-drinking hydrotherapy regimen consisting of eight 200-mL glasses of plain water daily for seven consecutive days and assessing both blood glucose levels and anxiety at multiple time points. This approach provides a short-term evaluation of the potential metabolic and psychological effects of a simple, low-cost, and readily applicable complementary intervention among patients with T2DM. Therefore, this study aimed to determine the effectiveness of oral water-drinking hydrotherapy on blood glucose levels and anxiety among patients with T2DM at RSU Sriwijaya Palembang.

METHODS

A quantitative quasi-experimental study with a pretest–posttest design was conducted among patients with type 2 diabetes mellitus at the Internal Medicine Outpatient Clinic of RSU Sriwijaya Palembang, South Sumatra, Indonesia, in 2026. Participants were selected using purposive sampling based on predetermined inclusion and exclusion criteria. A total of 42 respondents participated in the study, comprising 21 respondents assessed for blood glucose outcomes and 21 respondents assessed for anxiety outcomes.

The intervention consisted of consuming eight 200-mL glasses of plain water daily, equivalent to approximately 1,600 mL per day, for seven consecutive days. Participants were instructed to maintain their usual diabetes self-management practices, including dietary patterns, physical activity, medication adherence, and routine fluid intake. Blood glucose levels were measured using a glucometer two hours after the morning meal on days 1, 3, 5, and 7, while anxiety was assessed using the Hamilton Anxiety Rating Scale (HARS) at the designated measurement points. These assessments were performed before and after the intervention to evaluate changes in blood glucose levels and anxiety during the seven-day intervention period.

Data were analyzed using SPSS. Descriptive statistics were used to summarize participant characteristics and study variables. Changes in blood glucose levels and anxiety scores before and after the intervention were analyzed using the paired-samples *t*-test, with statistical significance set at $p < 0.05$. Cohen's *d* was calculated to determine the magnitude of the observed effects. Analyses were performed separately for blood glucose and anxiety outcomes across measurements on days 1, 3, 5, and 7.

Written informed consent was obtained from all participants before data collection. Participation was voluntary, and participants were informed of their right to withdraw from the study at any time. Participant confidentiality was maintained through the use of identification codes, and all research data were securely protected.

RESULTS AND DISCUSSION

Participants in both groups were predominantly female, accounting for 81.0% of the blood glucose group and 71.4% of the anxiety group ([Table 1](#)). In the blood glucose group, elementary education was the most common educational level (42.9%), whereas in the anxiety group, participants with no formal education and those with elementary education were equally represented (42.9% each). The mean age was 44.14 ± 8.38 years in the blood glucose group and 42.43 ± 8.91 years in the anxiety group, while the mean duration of diabetes was 5.86 ± 1.46 years and 6.10 ± 1.84 years, respectively. Overall, the participant characteristics indicated comparable age and duration of diabetes between the two groups.

Table 1. Characteristics of Participants

Characteristics	Blood glucose group (n=21)	Anxiety group (n=21)
Sex	n	(%)
Male	4 (19.0)	6 (28.6)
Female	17 (81.0)	15 (71.4)
Education	n	(%)
No formal education	7 (33.3)	9 (42.9)
Elementary school	9 (42.9)	9 (42.9)
Junior high school	5 (23.8)	3 (14.3)
Age, mean $\pm$ SD (years)	44.14 $\pm$ 8.38	42.43 $\pm$ 8.91
Duration of diabetes, mean $\pm$ SD (years)	5.86 $\pm$ 1.46	6.10 $\pm$ 1.84

The mean blood glucose levels decreased following the intervention at all measurement points. The mean blood glucose level decreased from 232.7 to 218.2 mg/dL on day 1, from 218.9 to 204.8 mg/dL on day 3, from 203.5 to 191.5 mg/dL on day 5, and from 189.8 to 177.4 mg/dL on day 7 (Table 2). The lowest post-test mean was observed on day 7 (177.4 $\pm$ 10.68 mg/dL), indicating a consistent downward trend in blood glucose levels throughout the seven-day intervention period.

Table 2. Blood Glucose Levels Before and After Hydrotherapy

Measurement Day	n	Pre-test, Mean $\pm$ SD (mg/dL)	Post-test, Mean $\pm$ SD (mg/dL)
Day 1	21	232.7 $\pm$ 15.39	218.2 $\pm$ 13.05
Day 3	21	218.9 $\pm$ 14.41	204.8 $\pm$ 12.63
Day 5	21	203.5 $\pm$ 15.71	191.5 $\pm$ 14.47
Day 7	21	189.8 $\pm$ 11.95	177.4 $\pm$ 10.68

Anxiety scores showed a fluctuating pattern throughout the seven-day intervention period. On day 1, the mean pre-test and post-test scores were identical (36.81) (Table 3). On day 3, the mean anxiety score decreased from 37.29 to 35.95; however, the scores increased from 34.76 to 35.43 on day 5 and from 37.52 to 37.67 on day 7. Thus, unlike the blood glucose levels, the anxiety scores did not demonstrate a consistent downward trend following the intervention.

Table 3. Blood Glucose Levels Before and After Hydrotherapy

Measurement Day	n	Pre-test, Mean $\pm$ SD	Post-test, Mean $\pm$ SD
Day 1	21	36.81 $\pm$ 7.58	36.81 $\pm$ 7.94
Day 3	21	37.29 $\pm$ 7.91	35.95 $\pm$ 9.45
Day 5	21	34.76 $\pm$ 7.55	35.43 $\pm$ 9.46
Day 7	21	37.52 $\pm$ 8.25	37.67 $\pm$ 9.13

Normality was assessed using the Shapiro–Wilk test, and all pre-test and post-test measurements of blood glucose and anxiety yielded p -values > 0.05 (Table 4). These findings indicated that the data met the normality assumption at each assessment point. Therefore, the paired-samples t -test was considered appropriate for the subsequent analysis.

Table 4. Shapiro–Wilk Normality Test

Variable	Measurement	Shapiro–Wilk <i>p</i>
Blood glucose	Day 1 pre-test	0.669
Blood glucose	Day 1 post-test	0.957
Blood glucose	Day 3 pre-test	0.879
Blood glucose	Day 3 post-test	0.476
Blood glucose	Day 5 pre-test	0.569
Blood glucose	Day 5 post-test	0.825
Blood glucose	Day 7 pre-test	0.548
Blood glucose	Day 7 post-test	0.245
Anxiety (HARS)	Day 1 pre-test	0.255
Anxiety (HARS)	Day 1 post-test	0.065
Anxiety (HARS)	Day 3 pre-test	0.137
Anxiety (HARS)	Day 3 post-test	0.410
Anxiety (HARS)	Day 5 pre-test	0.699
Anxiety (HARS)	Day 5 post-test	0.476
Anxiety (HARS)	Day 7 pre-test	0.303
Anxiety (HARS)	Day 7 post-test	0.229

The paired-samples *t*-test demonstrated statistically significant reductions in blood glucose levels following the intervention on all measurement days, with $p < 0.001$ (Table 5). The mean reductions ranged from 12.0 to 14.5 mg/dL, with the largest reduction observed on day 1 (14.5 mg/dL) and the smallest on day 5 (12.0 mg/dL). Cohen’s *d* values ranged from 2.907 to 3.739, indicating very large effect sizes across all measurement days.

Table 5. Effect of Hydrotherapy on Blood Glucose Levels

Measurement Day	Pre-test Mean	Post-test Mean	Mean Difference	<i>t</i>	<i>p</i>	Cohen’s <i>d</i>
Day 1	232.7	218.2	14.5	13.32	<0.001	2.907
Day 3	218.9	204.8	14.1	15.52	<0.001	3.388
Day 5	203.5	191.5	12.0	17.13	<0.001	3.739
Day 7	189.8	177.4	12.4	15.47	<0.001	3.376

Analysis using the paired-samples *t*-test revealed that anxiety scores did not differ significantly between the pre-test and post-test measurements on any assessment day, with *p*-values ranging from 0.235 to 1.000 (Table 6). The mean anxiety score decreased only on day 3 (by 1.34 points) but increased slightly on days 5 and 7. Cohen’s *d* values ranged from –0.122 to 0.267, indicating negligible to very small effect sizes. These findings suggest that the intervention did not produce a statistically significant change in anxiety scores during the seven-day observation period.

Table 6. Effect of Hydrotherapy on Anxiety Scores

Measurement Day	Pre-test Mean	Post-test Mean	Mean Difference	<i>t</i>	<i>p</i>	Cohen’s <i>d</i>
Day 1	36.81	36.81	0.00	0.000	1.000	0.000

Day 3	37.29	35.95	1.34	1.224	0.235	0.267
Day 5	34.76	35.43	-0.67	-0.560	0.582	-0.122
Day 7	37.52	37.67	-0.15	-0.123	0.903	-0.027

This study found that oral water-drinking hydrotherapy was associated with a consistent reduction in blood glucose levels among patients with type 2 diabetes mellitus (T2DM), whereas anxiety scores did not show statistically significant or consistent changes during the seven-day intervention. Blood glucose levels decreased at every measurement point, with mean reductions ranging from 12.0 to 14.5 mg/dL and very large standardized effect sizes (Cohen's $d = 2.907$ – 3.739). In contrast, anxiety scores fluctuated throughout the observation period, with no significant pre-post differences ($p > 0.05$) and negligible-to-small effect sizes (Cohen's $d = -0.122$ – 0.267). These findings indicate that physiological and psychological outcomes may respond differently to the same short-term hydration intervention.

The reduction in blood glucose observed in the present study is consistent with previous findings suggesting an association between water intake and glucose regulation in patients with T2DM. [Johnson et al. \(2017\)](#) reported that reduced water intake impaired glucose regulation in patients with T2DM, indicating that inadequate hydration may adversely affect glycemic responses. Conversely, [Sedaghat et al. \(2021\)](#) found that pre-meal water intake was associated with improved glycemic control and reduced fasting blood glucose among patients with T2DM. Similarly, [Enhörning et al. \(2019\)](#) demonstrated that increased water intake was associated with reductions in plasma copeptin and glucose-related outcomes. The present findings therefore support previous evidence that adequate water intake may contribute to improved glycemic regulation. However, differences in intervention duration, timing and volume of water intake, participant characteristics, and glucose measurement procedures should be considered when interpreting the consistency of these findings.

The reduction in blood glucose observed in this study may be related to physiological mechanisms associated with hydration status and arginine vasopressin (AVP) regulation. Adequate water intake may reduce the physiological stimulus for AVP secretion, with copeptin serving as a stable surrogate marker of AVP activity. Previous studies have suggested that increased water intake can reduce copeptin concentrations and may influence glucoregulatory processes ([Enhörning et al., 2019](#); [Lemetais et al., 2018](#)). In addition, hydration-related AVP pathways have been proposed to play a role in metabolic regulation, while higher water intake and lower urine osmolality have been associated with a more favorable metabolic profile at the population level ([Brunkwall et al., 2020](#); [Carroll & James, 2019](#)). These mechanisms may provide a physiological explanation for the reduction in blood glucose observed in the present study. However, because AVP and copeptin were not directly measured, this proposed mechanism should be interpreted as a possible explanation rather than a confirmed mediator of the observed change.

In contrast to the findings for blood glucose, oral water-drinking hydrotherapy did not produce a statistically significant change in anxiety scores during the seven-day intervention period. The effect sizes were negligible to very small, indicating that the observed changes in anxiety were minimal. This finding suggests that the potential effects of increased water intake may be more evident for metabolic outcomes than for psychological outcomes during a short intervention period. Although anxiety is an important psychological concern among individuals with T2DM, previous evidence has primarily demonstrated an association between diabetes and anxiety rather than the effectiveness of hydration-based interventions for reducing anxiety ([Amiri & Behnezhad, 2019](#); [Mersha et al., 2022](#)). Therefore, the absence of a significant change in anxiety in the present study

does not contradict the established relationship between diabetes and anxiety but rather indicates that oral water-drinking hydrotherapy alone may not be sufficient to produce a measurable short-term psychological effect.

Several factors may explain the absence of a significant reduction in anxiety scores. First, the seven-day intervention may have been sufficient to produce physiological changes related to hydration and glucose regulation but too short to induce meaningful psychological changes (Cousins *et al.*, 2019). Anxiety is influenced by multiple factors, including concerns about disease progression and complications, treatment burden, coping ability, social circumstances, and individual psychological characteristics, which may not be substantially modified by increased water intake alone. Previous studies have shown that psychological and behavioral interventions specifically targeting emotional and self-management processes can improve psychological outcomes and glycemic control among adults with T2DM (Upsher *et al.*, 2021; Winkley *et al.*, 2020). Therefore, interventions that directly address psychological mechanisms may be more appropriate when anxiety reduction is the primary therapeutic goal.

From a clinical perspective, oral water-drinking hydrotherapy may be considered a simple, low-cost, and easily implemented complementary approach to support diabetes self-management and adequate fluid intake. However, it should not replace prescribed pharmacological therapy, dietary management, physical activity, or other evidence-based diabetes care. This study has several limitations that should be considered when interpreting the findings. The quasi-experimental pretest-posttest design without a randomized control group limits causal inference, while the relatively small sample and single-center setting may restrict the generalizability of the findings. In addition, potential variations in dietary intake, physical activity, medication adherence, and other factors that may influence blood glucose were not fully controlled. Furthermore, physiological markers such as AVP and copeptin were not measured, preventing direct assessment of the proposed hydration-related mechanism. The short intervention period may also have limited the ability to detect changes in anxiety. Future studies should employ randomized controlled designs with larger samples, longer follow-up periods, and more comprehensive control of potential confounding factors to further evaluate the effects of oral water-drinking hydrotherapy on glycemic and psychological outcomes.

CONCLUSION

Oral water-drinking hydrotherapy was associated with a significant reduction in blood glucose levels among patients with type 2 diabetes mellitus over the seven-day intervention period. However, the intervention did not produce a significant change in anxiety levels. These findings suggest that oral water-drinking hydrotherapy may serve as a simple and accessible complementary intervention to support glycemic control in patients with type 2 diabetes mellitus. Nevertheless, its potential effect on anxiety requires further investigation through studies involving larger samples and controlled research designs.

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AUTHOR CONTRIBUTION

All authors participated in the study conception and design, data acquisition and analysis, interpretation of the results, and manuscript preparation. They also contributed to the critical review and revision of the manuscript for substantive intellectual content. All authors approved the final manuscript and accepted responsibility for the integrity and accountability of the work in its entirety.

CONFLICT OF INTEREST

The authors declare that there are no conflicts of interest related to the publication of this article.

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